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Transformation Trends in Food Logistics for Short Food Supply Chains – What is New?

The way in which food reaches consumers is a high profile component of the food chain's Greenhouse Gas (GHGs) emissions, but is changing rapidly as technology facilitates online and new targeted logistic solutions which deliver directly to the consumer's home, workplace or other convenient locations. The challenge is how can new, more fragmented supply chains be developed without increasing GHGs emissions. More broadly speaking, digitalisation is transforming how all food logistics functions. This allows consumers to connect more directly with both farmers and food producers, in Short Food Chains (SFCs), which help the former to understand more about the source of their food and how it was produced. This paper aims to analyse the current SFCs' challenges, with particular attention paid to fresh products, taking into account the evolution of consumers and market trends as well as the transformation of logistics. The analysis is based on evidence and examples from across Europe. New direct delivery food logistics models could help consumers access supplies of fresh products more easily, improve consumer health and reduce the high waste levels and carbon emissions, which represent key challenges for many European fresh product supply chains. Food suppliers would also benefit by securing more of the final consumer value of the food they produce.

Keywords: short food chains, logistics, fresh products, perishability, new trends, sustainability

JEL classifications: Q13, Q18

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Introduction

Food logistics are a key part of the food chains, connecting producers with consumers. The way in which food logistics occurs has changed substantially and the modern food industry has been shaped by these changes (Martikainen *et al.*, 2014). For example, before the railways were built in the 19th and early 20th Centuries, virtually all fresh food was produced close to the point of consumption. As transport became faster, producers of fresh produce were freed from the need to produce close to the market, typically one day's horse and cart distance, and the market gardens which surrounded most towns and villages in the Middle Ages were replaced with more concentrated areas of specialised production (Braudel, 1982). These concentrated areas of production, based on soil, topography and climatic advantages, produced much more fresh produce than their local community could consume, with the excess production taking advantage of new faster logistics to access the cities and larger towns. Since the end of World War 2, the use of railways has been replaced in many areas by lorries which transport food over long distances using much improved road networks (Hayter, 1997).

As transport distances lengthened, the food chain became more efficient both economically and environmentally, as most of the GHGs emissions in the food chain relate to production, in agriculture primarily, and therefore the more efficient farm production that was enabled more than outweighed the extra GHGs emissions from logistics (Jones, 2002). New SFC models can increase the GHGs per unit of food, if they either reduce transport efficiency per unit of product or increase waste in the supply chain. For fresh products, with shorter shelf lives (such as fruit and vegetables), the arrival of cool chain technology further revolutionised the potential to transport fresh products, but cool chains use a lot of energy and as a result can increase the GHGs per unit of food. Much of Northern Europe receives large consignments of fresh products from Southern Europe, particularly in winter time, with most of the produce transported by refrigerated lorry (do Nascimento Nunes, 2014).

In recent decades, however, consumers have become concerned that these long supply chains, which are long not only in distance terms, but also because they tend to include more steps (e.g. wholesalers, transport companies etc.), have broken the link between producer and consumer. Farmers have also become concerned that their share of the final value to the consumer has been reducing (Hesse and Rodrigue, 2004).

Arguably, we are now on the cusp of two major changes which may alter this trend towards more specialised areas of production, followed by long distance logistics. Firstly, production technology is allowing season extension, e.g. in Northern Europe the strawberry season is now over 7 months compared to 7 weeks in the 1980s and urban farming technology are beginning to allow year round production. In parallel, logistics technology is changing, with digitalisation allowing smaller consignment sizes and direct relationships between consumers and producers, addressing concerns of both: consumers who want to know more about where and how their food was produced; producers wanting to secure a larger share of consumer value (Kunze, 2016; Maslarić *et al.*, 2016; Van der Vorst *et al.*, 2005). The challenge in changing the logistics system is how new logistics models can be developed which are commercially competitive at the same time as reducing waste and GHGs emissions (Hesse and Rodrigue, 2004).

This paper discusses the main challenges that the food chain is facing, especially in the fresh produce sector, by analysing how new consumers/market trends and new tech-

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nology adoption influence logistics transformation. Additionally, the authors study the role of new food systems models, based on SFCs in influencing logistics transformation and the opportunity to increase sustainability by reducing food waste and GHGs emissions (Bloemhof et al., 2015). The paper ends with recommendations for how SFC fresh produce businesses, both farmers and food companies, can use new logistics technology and business models to develop more efficient short food chains.

Material and method

This paper is based on a review of literature and emerging issues/results obtained through the work of the EU Thematic Network on short food chains: the Short Supply Chain Knowledge and Innovation Network (SKIN) project. The SKIN project has, since late 2016 been working to collect examples of best practices and information on innovations which are changing the food supply chain, including distribution and logistics issues. Therefore, the study will discuss innovative approaches, methods or technologies from the pool of research knowledge the project accesses. Short Food Supply Chains embrace a wide range of concepts. A definition provided by EIP AGRI (2015) defines SFCs as those systems aiming at creating value by reducing the number of steps in the food chain from producer to consumer. According to the European rural development regulation (1305/2013), a 'short supply chain' means a supply chain involving a limited number of economic operators, committed to co-operation, local economic development, and close geographical and social relations between producers, processors and consumers.

The Innovation Challenge Workshops (ICWs) held by the SKIN project have considered the factors which are changing the way in which SFCs work, including specifically:

- Changes in consumer demands and business models for fresh products (ICW, Belgium and the Netherlands, April 2018 and project visits in Austria in January 2018) which looked at how farmers are reconfiguring their businesses and supply chains to meet changing market needs;
- Changes in technology which allow new logistics and production (ICW, Budapest, September 2018) processes enabled in the main by the move to digitalisation.

In addition, other SKIN ICWs looked at related changes in food chain structures including: the regulatory framework (ICW Poland November 2018) for food; skills in the food chain workforce (Dublin, February 2019); and consumer values (Paris, April 2019). Each ICW brought together SKIN consortium members with local stakeholders from farming, industry, the public sector and regulatory bodies to debate the changes in the food chain. The paper below reports on and collates the findings from these events and workshops.

The main forces which are reshaping the food chain include: digitalisation and the resultant new possibilities for food chain structure and logistics; a focus on food waste and efficiency; changing consumer demands and interests in provenance and traceability. This paper focuses mainly on the logistics within the food chain, but draws on feedback from consumer interests and considerations of waste and efficiency in doing this.

Food Chain and Logistics

The food chain is the link between where food is originally produced on farm, where it is processed, stored and distributed to consumers. Each stage of the chain will involve logistics which move food or the products used to produce and protect food from business to business in the food chain. Long term, there has been steady growth in global trade volumes, with the value of global product trade rising by +32% to $16 trillion from 2007-'16 (WTO, 2018) even during recovery from the 2007-2010 economic downturn. Whilst this was a big fall from the +124% growth seen from 19962006, it shows that the value of World trade continued to grow even during slow growth periods.

More recent analysis suggests, however, that the slowing of global trade is continuing, with Lund *et al.* (2019) reporting that, whilst global trade continues to grow the proportion of goods which are traded is falling. This move to more local supply chains is being driven by consumers' propensity to choose regional products, new automated production methods which are levelling the playing field between locations (notably by reducing the advantages of low labour costs) and the growth in wealth levels in markets which were traditionally poor to more production for local consumption. In the food sector these factors are expected to lead to more local production, with more consumers interested in regional food provenance, technology changing how food is produced and consumers becoming wealthier.

Globally the world is seeing increased demand for food with reports suggesting this will continue until at least 2050. The reasons for increased demand have been studied by many reports, the first substantive report being FAO (2009) which predicted that global food demand would rise by 50% by 2030 and 60-100% or more by 2050 (compared to 2010).

The global food retail sector was worth $4.3 trillion in 2015 and growing at 6% per annum (USDA, 2013). Whilst data for the food service sector is less readily available, the share of consumer expenditure spent on food service varies substantially between rich countries (now similar to food retail) and poor countries where the food service sector is still very small. Globally food service is growing as wealth rises. Using the best estimates available for the food service sector suggests that the total food market is worth over $8 trillion.

The food chain is still seeing consolidation and a growth in global food flows, with this process anticipated to continue as the scale of the food sector globally continues to grow and countries specialise production.

Global shipping is very concentrated with consolidation continuing. Alphaliner's Top 100 states that in 2015 five of the biggest shipping companies dominated the global shipping industry and accounted for about 70 percent (Hellenic Shipping News, 2019) of the global market: APM-Maersk; Mediterranean Shipping Co.; CMA CGM Group; Cosco

Shipping Co. Ltd.; Hapag-Lloyd. This trend is supported by global food companies (e.g. Nestle, Unilever) and traders (e.g. Glencore), who wish to have a small number or single global logistic partner(s). This concentration and focus on unit costs is a key reason for growth in the global food chain, creating low cost competition for SFC producers. However, the EU food chain remains a large and complex sector, with 500 million consumers and sales (2015) of €1.115 trillion. The food and drink industry is the largest manufacturing employer in Europe with 4.51 million staff (15% of manufacturing employment), and is the largest manufacturing sector (15.2% of manufacturing turnover). The food supply chain starts with 11 million farmers and 94,000 fish producers, is sold by 63,000 agricultural wholesalers, processed by 293,000 food and drink manufacturers, distributed by 277,000 food and drink wholesalers, with 134 major food retail groups and 904,000 food and drink points of sale (Food and Drink Europe, 2018) and accounted for 13.8% of household expenditure in 2016.

This scale and complexity means that food logistics and distribution is a very complex and arguably inefficient system, increasing costs for everyone in the supply chain, including consumers. This also presents real challenges in the adoption of end-to-end, single systems to transport food, particularly as many of the companies in the food chain are very small and dispersed. The success of the large retail groups and multi-national food companies can in part be attributed to their focus on supply chain efficiency, with consolidation, regional distribution centres and the use of heavy goods vehicles used to drive down unit costs.

The Fresh Produce Sector

Fresh products are products without any thermal or other processing grown locally without any type of preservation before storage. Whilst fresh products cover a wide range of products from fruit, salad and vegetables to meat and unprocessed dairy products, this paper focuses on fresh produce: salads; vegetables; fruit. The fresh produce sector is a large and dynamic sector in the EU and presents particular challenges for food logistics as most of its products have a short shelf life and need to be part of a cool chain to reduce waste, unless consumed very close to where they were produced soon after harvest.

In the US fresh fruit and vegetables are defined as: fresh fruits and fresh vegetables include all produce in fresh form generally considered as perishable fruits and vegetables, whether or not packed in ice or held in common or cold storage, but does not include those perishable fruits and vegetables which have been manufactured into articles of food of a different kind or character. Furthermore they add that: the effects of the following operations shall not be considered as changing a commodity into a food of a different kind or character: water, steam, or oil blanching, battering, coating, chopping, colour adding, curing, cutting, dicing, drying for the removal of surface moisture; fumigating, gassing, heating for insect control, ripening and colouring; removal of seed, pits, stems, calyx, husk, pods rind, skin, peel, et cetera; polishing, precooling, refrigerating, shredding, slicing, trimming, washing with or without chemicals; waxing, adding of sugar or other sweetening agents; adding ascorbic acid or other agents to retard oxidation; mixing of several kinds of sliced, chopped, or diced fruit or vegetables for packaging in any type of containers; or comparable methods of preparation. This definition thus means that minimally processed fruit and vegetables are still considered fresh produce.

According to FAOSTAT (2019), Europe (EU and other European states) has a very large fresh produce industry. Fruit covered 7.2 million hectares in 2017, with output of 77 million tonnes worth $92 billion in 2016. Vegetables covered 3.7 million hectares in 2017, with output of 96 million tonnes of vegetables worth $50 billion in 2016. The sector is present in every state in Europe, but the crops and production systems used vary greatly across Europe.

According to Kyriacou and Rouphael (2018) quality is determined both by pre-harvest conditions and inputs and post-harvest treatment. They state that 'the potential quality of fresh fruits and vegetables in the horticultural supply chain is defined in the period preceding harvest, however the full development of quality characteristics can be optimised through the use of appropriate post-harvest technology. The use of post-harvest technology for fresh produce focuses heavily on conditions during logistics, both transport and storage, with the adoption of appropriate technology improving quality for consumers and reducing food waste and environmental impact' (do Nascimento Nunes, 2014).

The Challenge of Food Waste and Greenhouse Gas Emissions

Population growth as well as current production and consumption models are severely affecting the environmental impact of economic activity in terms of global warming, resource depletion and extinction of species. Therefore, the sustainability of food supply chains is becoming a key challenge to the world. Managing food supply chains is complex and involves multiple agents and processes, ranging from production to manufacturing, logistics and retail activities with each making different contributions to the overall sustainability of a product. Food Supply chain (re)design approaches suggested in the literature recognise the potential and increasing need to consider the system/network as a whole, as integrated approaches and collaboration between agents can yield greater benefits in terms of optimisation and raise standards (Higgins *et al.*, 2010; Van der Vorst *et al.*, 2009). It is therefore important to consider the supply chain as a whole, in order to reduce the environmental impact of a product.

The food sector has to manage the complexities generally dealt with in supply chain management, but with the added problem that its products are perishable (Van der Vorst *et al.*, 2005). In recent years food waste has become a growing problem: reducing food losses and waste is considered to be one of the most promising policy measures to improve food security in future and is receiving a lot of attention from institutions (van Boxstael *et al.*, 2014). Wasting food in the supply chain affects consumers economically and creates additional environmental impacts (Eriksson *et al.*, 2012). According to the FAO (2013) the global carbon footprint (CF) of annual food wastage is about 3.3. Gt CO_2 equivalent (CO_{2eq}). The amount of food waste in Europe is estimated to be 88 million tons and to cost €143 billion per annum (European Commission, 2016). Perishable products are among the most wasted food items in supply chains and households and fruit and vegetables usually account for the highest proportion of food waste in developed countries (Stefan *et al.*, 2013).

In Europe, the consumption of food accounts for about 20-30% of GHG emissions from all products, and globally, agriculture is the primary cause of increasing atmospheric concentrations of CH_4 and N_2O and produces 10-12% of total anthropogenic GHGs emissions (Tukker *et al.*, 2006). The World Resources Institute (2019) estimates that the total food chain impact on GHGs emissions is 25-30%: with agriculture directly responsible for 13.8% of emissions, a further 1.4% coming from agricultural energy use, 1% for food chain energy use and 12.2% due to land use change most of which is cleared for agriculture. Transportation generates 14% of total emissions, both at global and EU level (Stern, 2018) and it is the main source of CO2, NOx, SO2 and PM production. In this context, logistics management plays an important role in sustainable performance, particularly as far as the short food supply chain is concerned (Heitz *et al.*, 2019). The impact of this phase depends on the mode of transport: plane, ship, truck, rail, barge or pipelines. Each mode has different characteristics in terms of environmental and economic performances (reduction of GHG and increased fuel efficiency), transit time, accessibility, speed and it depends on the kind of product to covey and distance to be travelled (Dekker *et al.*, 2012). Another important aspect related to the sustainability of food supply chains are the inventories, which should be minimised with just-in-time production. In addition, the optimisation of one's distribution centre location can positively affect transport efficiency in terms of both costs and environmental impact. Concluding, one of the key issues in green logistics is the identification of "Eco-efficient" solutions as balancing environmental and economic supply chain performances (Quariguasi *et al.*, 2009; Canfora, 2016). In this context SFCs represent a new model able to achieve the environmental goals as legally defined by reg. 1305/13, because it reduces the environmental impact (GHG emissions) by reducing the logistics impact linked to transportation costs. Furthermore, SFCs promote biodiversity and contribute to peri-urban agriculture development (Canfora, 2016).

Logistics transformation and Short Food Chains: the importance of changes

The food industry is working to adopt SFCs, with fewer commercial steps in the chain to increase provenance and efficiency. As this process proceeds changes in the structure of the supply chain are anticipated (Blanquart *et al.*, 2010). Regional and local SFCs tend to deal with smaller volumes of food and drink and this can make it hard for them to compete on costs terms with established food chains, dominated by the 134 large food and drink retailers in Europe and larger food processors (EIP-AGRI, 2015).

Smaller volumes in each consignment tend to increase unit costs in both financial and environmental terms per unit of consumption. This inconvenient truth is a challenge for SFCs whose consumer appeal is often based on promoting ecological, environmental, health and local benefits, all of which are premised on the promise that these products are more sustainable. It is therefore essential for SFCs to find ways to deliver environmentally efficient logistics systems to reach consumers (Kneafsey *et al.*, 2013).

This challenge is becoming harder due to another change which the food chain needs to respond to, continuing urbanisation, with the UN predicting in 2007 that the percentage of the European population living in urban areas, 72% in 2007, would continue to climb, reaching 84% by 2050 (UN, 2014). With many SFCs producers based in remote rural areas, continued urbanisation of their customer base presents a logistical challenge and potentially increases financial and environmental costs of logistics. To address this, it is important for SFC producers to look at ways in which they can collaborate with other businesses to deliver efficient logistics. The potential for new technology to help has been reported by many projects on SFCs and the next section explores the potential of these new technology systems and business models (Maslarić *et al.*, 2016).

New logistics Models for Short Food Chains

Within the framework of SFCs new logistics models are emerging and SFCs producers routinely report that the costs and complexities of logistics are a major constraint on growth. The SKIN project has identified interesting examples of new distribution and logistics models which help producers at the same time as making SFCs products more accessible to consumers. In January 2018, a SKIN event reviewed the progress of a number of kiosk/unmanned food vending units which sell products direct to consumers.

These vending units either have a computer interface which allows consumers to buy products which are then released to them or they are based on a trust model, normally backed up with a CCTV system, which trusts consumers to pay for what they take. A similar trust model is found in Ukraine in the Lviv region near the Kyiv-Chop highway in the village of Banyuniny Kamyanka-Buzky. A local producer Mikhail Kostyuk (Store and Road) founded a trust store, which is expanding quickly and now has three units. There are no staff, but instead price tags and the inscription 'Self-service'. Drivers work out how much they owe for the products they want and pay in a three-litre can with a hole for money to be posted in. Mikhail says 'no one is stealing anything, we are ready to open the door to Europe'.

Shared distribution and logistics models take many forms and include: collaborations of farmers and small food producers such as witnessed during the SKIN project Innovation

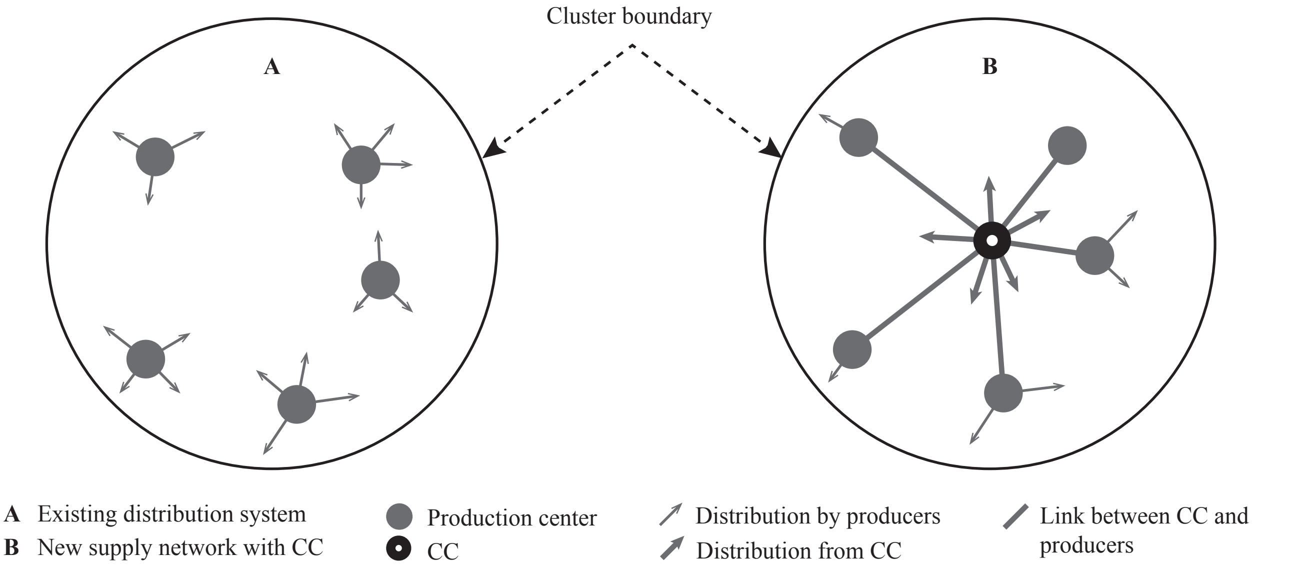

Figure 1: Logistics and Supply Chains in Agriculture and Food.
Source: Gebresenbet and Bosona (2012)

Challenge Workshop visit to Franken Agro in April 2018. Their Fresh from the Farm delivery service combines the outputs from 14 farmers and offers a delivery service to commercial customers, sharing the costs of logistics between the participating farmers. An interesting feature of these systems is that sales are made under one brand, supported by and on behalf of clusters of brands from independent businesses. Similar collaborative ventures are found in the UK, including Ashlyns Organics and Woburn Country Foods, both of whom combine supplies from over 25 farmers and deliver to food service and retail customers near London.

These new models all depend on clusters of businesses working together. In a study conducted by Gebresenbet and Bosona (2012), looked at supply chain clusters in agriculture and food (Figure 1) and reported that these clusters can have both positive and negative outcomes. Small producers in these clusters do not need marketing strategies and business plans and functions such as logistics and sales are outsourced. Moreover, they are in tight collaboration with other companies. However, they lose independence and if some cluster members have quality problems this reflects badly on all those involved in the cluster.

There are multiple examples of how new technology is changing the way produce is sold. For example, the KATANA project introduced an innovative start-up which developed an iPhone app to link farmers' products to a local restaurant. In Slovakia, a SKIN best practice, Labas FRESH, has developed a call centre to distribute regional fresh products.

In big cities, services such as Just Eat and Deliveroo, are using bicycle or moped couriers to deliver food directly to consumers. Glovooffers is a similar service in Spain, France, Italy, Portugal, Ukraine and South America, which uses an app-based delivery service.

The proliferation of new digitally enabled distribution services also includes FARMDROP; join food chain; green market co., get go kart, and, many others. It is unlikely that all these new online systems will survive, but their collective impact and disruptive nature, signals substantial change in how food is purchased and distributed.

SFCs are very well suited to the adoption of new marketing and logistics systems given that logistics is a key challenge for SFCs; thus, systems that facilitate more efficient logistics or reduce the need for logistics services are beneficial. It means that: they do not have big transport costs for deliveries; services using bicycles or mopeds are seen as environmentally friendly; they are suited to local delivery and close connection between consumers and producers; they can reduce infrastructure needs; they can be more flexible to fit with busy lives; and they can be aligned with local food strategies developed by the public sector.

A key challenge for all alternative logistics solutions is that they reduce the volume of food transported by each vehicle. Whilst a moped or small van may seem a very efficient and low impact vehicle, in practice a moped will only transport a few tens of kilos of food, compared to 25 tonnes for a full size articulated lorry. The fuel costs per kilo can thus increase per kilometre per kilo through using smaller vehicles.

Most SFCs are therefore only more efficient from an environmental perspective, if the longer part of the supply chain is undertaken using a large lorry, with the 'last kilometre' using a smaller vehicle such as a light van or moped. Perhaps counter-intuitively, this problem can also exist if consumers travel further to visit a farm, for example urban consumers travelling out to the countryside, to buy their food direct if they do this by car. Each family will only buy a few kilos of product and the combined GHGs emissions of all these car journeys can be orders of magnitude higher than if the farmer uses a lorry to transport their product to the city or town. Of course, consumers benefit by meeting the farmer in terms of their reconnection with the source of their food, but it can increase the GHGs emissions associated with the supply chain.

The conclusions of the ICWs run by SKIN is that further work is needed to design new hub and spoke SFCs supply chains which optimise GHGs emissions at the same time as unlocking consumer and farmer value.

Use of Technology in Logistics

Physical logistics is only one part of the distribution system connecting SFCs producers with consumers. In most cases logistics are provided as a service or addendum to the main product and so it is critical to understand how the supply chain works and consumers buy food and drink products.

The food chain is witnessing rapid changes in its structure and thus logistics needs, as consumers change where and how they buy food. The growth of online retailing is accelerating with £1 in £5, i.e. 20% by early 2019 of the UK retail sector now online, with online retail growing by over 13% from 2017-18 (ONS, 2018). However, UK food retailing taking place online is only 5.5%. Similar patterns of growth are being seen across many countries in Europe, but the degree of retail sales online and the percentage of consumers who buy online varies greatly, with fresh food generally having a smaller percentage of online retail than other sectors, such as clothing. Statista (2018) states that 7.5% of total global online grocery sales were in the UK and 5.6% in France, but only 0.5% in the similar sized Italian market, which suggests that parts of Europe have substantial potential for growth in online sales. Growth in 2016 was reported as being fastest in Central and Eastern Europe with online retail sales in Romania increasing by 38% and by 35% in Slovakia (ECommerce Europe, 2017).

Trend data suggests that further rapid growth in online food retail can be expected as platforms and delivery services improve. A key challenge for fresh products delivery is the need to maintain cool chain integrity, because with many consumers not at home in the daytime this makes home delivery of fresh food challenging. If this challenge can be solved cost effectively, the potential for home delivery of fresh produce would be transformed.

Automation of deliveries is being trialled, with both drones and robots used in cities. A system developed in Estonia and developed into a commercial delivery robot, is being trialled by Tesco in some UK cities. The development of automation for food logistics is also being driven by the challenge of rising labour costs and challenges in finding lorry drivers. The potential for automation to address labour supply challenges in logistics with companies reporting that skill shortages lead to higher wages and this is increasingly tipping the balance in favour of automation.

In a recent review of how technology will impact the logistics industry, the UK Government Office for Science identified how 7 digitally enabled technologies will impact the logistics industry (Wang *et al.*, 2015): cloud computing; Internet of Things (IoT); social media networks; Artificial Intelligence (AI); big data analytics; immersive technologies; distributed ledger technology (e.g. blockchain). They concluded that these technologies will enable the development of smart and digitalised applications and have great potential to enhance the sustainability of transport in respect of its physical, environmental, economic and social dimensions. Currently, cloud computing and social media networks enjoy wider adoption than the others, with IoT closely following. They also conclude that both cloud computing and IoT have become the backbone of freight transport and logistics systems, whereas big data analytics and AI, though less mature, have received substantial private and public investment. They also report that empirical evidence suggests that AI, IoT, big data analytics and immersive technologies are likely to have the greatest impact in the future, given their potential for driving better decisions, increasing productivity, streamlining supply chains and developing new, data-driven business models. The review also identified challenges to the further adoption of emerging technologies, which include cost, lack of expertise, security, privacy and legal concerns, and an absence of standards.

Heavy investment is being made globally to increase the efficiency of food logistics systems and a key challenge for SFC producers is that, as these systems in the 'mainstream' food chain reduce costs, there will also be pressure on SFC producers to adopt similar systems to remain competitive. SFCs already struggle to deploy cost effective logistics, which is an even larger challenge for smaller producers in remote areas with weak infrastructure. It could be argued that SFC producers need to accept that they have to use logistics systems provided by other companies, who can deliver efficiently, or that groups of SFCs producers will need to collaborate on logistics.

Autonomous vehicles will be a key driver in the future of logistics with many warehouses now having fully automated warehousing e.g. Ocado and Amazon. However, for smaller producers there are also solutions that can be implemented such as autonomous forklift trucks. These autonomous systems allows organisations to operate 24/7, delivering cost savings by allowing haulage contractors to fit the supplier in when costs are lowest, by reducing the cost associated with lorry waiting time. For example, STILL is working on concepts to enable co-operation between several autonomous trucks. This would result in improved utilisation, avoidance of obstacles and a reduced waiting times. Whilst many of these systems are initially being developed in other sectors of the economy, once developed it is relatively easy to apply them to fresh produce.

Sasko Cuklev, Director of Autonomous Solutions, Volvo Trucks, has stated that (Volvo, 2019): "Transportation is really the lifeblood, the pulse of societies, it drives prosperity for business and the people. In the near future, we will start to see self-driving trucks from Volvo on our roads". The shift to autonomous vehicles brings benefits such as reduced haulage costs as the vehicles do not require breaks legally required for human drivers, but it also has the benefit of increased safety.

Amazon have been trialing their PrimeAir drone service in Cambridgeshire, United Kingdom since 2016, claiming that PrimeAir is a future delivery system designed to safely get packages to customers in 30 minutes or less using drones.

Looking further forward, there is considerable investment being made into new technologies to substantially reduce the logistics distance travelled by the finished product. This includes urban farming systems, which are currently heavily focused on fresh produce, as perishable high value products where production very close to the point of consumption brings benefits. Whilst more futuristic for fresh produce, for manufactured food products some commentators are predicting a bright future for 3D printed food. In terms of practical equipment, the Foodini is a 3D printer designed for the home kitchen. Food is prepared using a blender or processor and the mix is printed through the 3D printer to create the product. Whilst there would still be a need for the ingredients to be delivered, most of these would be preserved or ambient goods, meaning more efficient, lower cost logistics methods could be used.

As with the earlier discussions about consumers visiting farms to buy food direct, a key challenge for these new technology enabled food chain systems is that they can lead to higher GHGs emissions per kilo of food. Virtually every system being developed is focused on 'just in time delivery' of small quantities of food direct to the consumer, for example using drones or robots. At the extreme, a lorry with a 25 tonne load of food transports 5,000 times as much food as a robot delivering a 5 kilo consignment or 25,000 times as much food as a drone with a 1 kilo payload. The energy consumption and GHGs per kilo are therefore higher for the smaller delivery. This can be overcome to some extent through the use of hub and spoke models, in which the small consignment size is only used for the 'last kilometre'.

Tracking Systems

Consumer trust in food has been disrupted by food scares and this is leading to a focus on being able to prove food provenance and traceability. The food industry has used Hazard Analysis Critical Control Points (HACCP) for many years to manage accidental adulteration risks in food production. In the aftermath of scandals in the food sector, including: the use of Sudan Dyes; lamb takeaways which included no lamb; and finally, the Horsemeat Scandal in 2013 in which horse meat from Romania had its paperwork changed during its distribution across Europe, eventually being sold in UK supermarkets as beef, new controls have been introduced to reduce the risk of food being deliberately altered or threatened in the supply chain.

This has led to the development of Threat Analysis Critical Control Points (TACCP) and Vulnerability Analysis Critical Control Points (VACCP) (Leatherhead Food Research 2016), to reduce the risk of threats (commercially motivated changes to food) and vulnerabilities (terrorism or deliberate adulteration of food by criminals) in the food chain, particularly during transport.

The focus on provenance and traceability is a potential advantage for SFC producers, given that their supply chains are based on reducing the number of steps in the chain to the minimum and creating a direct link between consumers and the source of their food. However, even in SFCs it is common for third party companies to manage distribution and logistics. The need to use TACCP and VACCP systems is therefore still an increasingly common feature of SFCs.

Fresh produce wastage is a major issue for the food chain, with consumers increasingly concerned by waste, which is also a big cost for farmers and retailers. Cool chain technology can reduce these costs and technology is being used to monitor fresh produce in the supply chain to ensure cool chain integrity.

Tiny Tag manufacture 2 types of data loggers primarily used in the food chain, with costs now under €60 for the standard Transit 2 data logger to €320 for the Cryogenic data logger. These data loggers are lightweight and compact, allowing unobtrusive placement in food consignments and are compliant with EU regulations. Sigfox provides food systems to track food supplies in real time using battery devices, which transmit location data from fleets of returnable containers and report data on temperature, shock and tilt to provide better insights into quality control and traceability.

Companies are also beginning to investigate the potential for next generation technologies, such as blockchain, based on distributed ledger technology, to provide complete traceability from end to end in the food supply chain. IBM and Walmart are running a commercial trial in the USA (IBM) and Albert Heijn, in the Netherlands, has developed a trial blockchain solution for orange juice. The global shipping sector has been developing systems to deliver real time tracking and security of international freight. Maersk is leader in this field and started to use very-small-aperture terminal (VSAT) satellite technology in 2012. It is now used on all their vessels to provide real time tracking. Further system developments are being used to monitor conditions inside containers.

LINKFresh is a Microsoft ERP software package used by many fresh produce businesses to provide barcodes and traceability allowing them to track products on a mass balance system by consignment to see if product has been added or removed during logistics. All these technology based systems, whether focused on automated deliver, food tracking or quality monitoring, rely on food producers using Electronic Data Interchange (EDI) systems, which has been used for groceries since the 1970's. However, most small food producers do not have the internal systems to embrace EDI and this is a serious challenge in the adoption of these systems in SFCs.

The use of technology in the mainstream food chain has been focused on delivering efficiency until fairly recently. However, digital technologies can also be used to help consumers understand where and how their food was produced. The ability to scan a barcode or QR code and to be directed to a website giving information on the food appeals to many consumers. In practice most consumers will not use this technology most of the time, but the fact the information is available helps consumers to trust the authenticity and provenance of food. Providing this information electronically is expensive, but unless SFCs producers embrace this technology it is likely that one of the key advantages of SFCs, which consumers pay for, traceability and provenance, will be eroded as all mainstream food products will also provide this information.

Tracking systems in the food chain allow problems to be identified quickly, such as temperature spikes, which can help corrective action to be taken, in turn reducing food waste. This has a direct impact on greenhouse gas emissions in the food chain.

Next steps and future research

This paper has discussed how food logistics is changing and the specific role played by SFCs, both as a driver of change and as a recipient of change in logistics technology and business models. Consumers' needs are changing and new logistics models can respond to this, helping to create shorter chains in which consumers learn more about their food choices through closer connection with producers.

New technology and logistics business models are also changing rapidly and SFCs producers must understand how these changes will impact their businesses. Arguably SFCs are well placed to benefit from these changes as new technology and business models allow smaller producers, common in SFCs, to compete with larger companies without losing the economies of scale dedicated logistics have given larger producers in the past. If SFCs can compete on price, then all other things being equal, they are likely to see their market share grow because of the other benefits of provenance and traceability they provide. However, efficient logistics systems are critical to achieving this.

In the fresh produce sector, new logistics and supply chain models have to ensure they don't increase GHGs. The history of the last 200 years has largely been one of greater spatial specialisation in production and, if SFCs wish to develop more local and regional supply chains, they will also need to embrace new production technologies, as well as efficient logistics, to overcome the inherent environmental disadvantages of producing in less ideal climatic conditions. The transport of food in bulk is one of the least impactful parts of the food chain and so any marginal gains in GHGs emissions in transportation must not be lost due to less efficient farm production. Similarly, the trends towards personal delivery of food direct to consumers 'just in time' could, unless carefully managed, lead to a substantial increase in GHGs emissions as smaller consignment sizes are inherently less efficient in energy terms than larger consignments. Further work is needed to consider these environmental impacts of SFCs, given that GHG emissions and environmental impact have not been the driving force for the development of SFCs. Instead, to date SFCs have been developed primarily to help reconnection between consumers and the source of their food and to deliver higher financial returns to farmers and primary food processors. Looking forward there are other areas which need to be researched further to help the SFC fresh produce sector to deliver its potential. These areas include the need to understand: how consumers make fresh produce purchase decisions; how to encourage consumers to purchase more fresh produce, particularly seasonal products; which new logistics technologies offer the most potential for SFCs; how age, lifestyle and other factors affect consumer interest in and purchasing decisions for fresh produce. If the fresh produce sector can address these challenges at the same time as it embraces new logistics models, then the changes being seen in logistics could be a significant driver of growth in SFCs fresh produce supplies.

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